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Review Article

Why only a man turned out to be the owner of mind?

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Abstract

It is considered that the main distinguishing feature of *Homo sapiens* from other living beings is the presence of his mind. There are many hypotheses regarding the origin of the human mind. The complexity of the problem lies in the fact that it is impossible to experimentally test any of the existing hypotheses. Perhaps we will never fully know how the human mind arose, but it is necessary to strive for this. Here we discuss the possible causes of the origin of a large brain in modern man, implying that the mind is ultimately a product of the human brain. We believe that in order for such a large brain to arise, profound and possibly unique changes in the genome and in the human body had to occur, which did not take place in other higher primates. The role of the evolution of the karyotype and heterochromatin part of the genome in the immediate ancestors of *Homo s. sapiens*, which led to an increase in the level of heat conductivity of their bodies changed the existing mechanisms of thermoregulation and led to the appearance of hairless skin, which, together, led to a sharp increase in the size of the brain, with the ensuing consequences, is discussed. We believe that the increase of the human brain size was not the result of drastically changes of the structural genes. Most likely it was the consequence of more ordinary events, such as evolution of karyotype, constitutive heterochromatin in chromosomes, human body heat conductivity, skin and thermoregulation. An experimental test is proposed to test the hypothesis put forward.

Key words: origin of mind; human karyotype; human chromosomal heterochromatin; hairless skin; human thermoregulation; human body heat conductivity

Introduction

It is obvious that the mind is the most complex product of biological, cultural and social evolution. Therefore, the concept of mind is still the subject of controversy and heated discussions. It is no accident that modern psychology leaves the concept of "mind" in the sphere of philosophy and prefers to operate with the concept of intelligence. Although intelligence is not a purely human asset, and it is present to one degree or another in animals, it, unlike mind, is amenable to a more or less objective quantitative assessment. Unfortunately, it is not yet possible to somehow measure, weigh, transfuse, or perform any actions so that other independent researchers can get the same results.

Since mind is a philosophical category and it is possible to talk about it endlessly from the point of view of philosophy, we have limited ourselves to investigating only one aspect of the issue - its origin from a biological point of view. We are supporters of the view that there is nothing exceptional and supernatural in intelligence and it is the result of a long adaptive evolution. Although in the future, for the convenience of presentation, the more familiar term mind is used, instead of the word intellect, we mean something natural, which is a product of the brain, the device and operation of which are quite accessible to scientific analysis.

The question of why the mind arose only in man and what is there in him that other living beings lack has been worrying humanity for a long time? Almost all the “explanations” are variants of social hypothesis relating to the pressures produced by factors such as food gathering, hunting, scavenging, home base behavior, defense against carnivores, and the need to communicate within relatively large social groups [1-5].

From the point of view of biology, a long list of morphophysiological features of a man is usually given as an answer to this question, such as large neocortex, high physiological plasticity, perfect system of physiological thermoregulation, the structural features of the upper limbs, unique sexual and reproductive behavior, homoiothermic, the presence of a sensory system and a natural instrument, optimal for small manipulations with objects that, to one degree or another, contributed to the emergence of the big brain. This, of course, is not a complete list of human characteristics related to the emergence of the human mind, and it will undoubtedly be replenished as our knowledge develops. We want to add to this list the possible role of the evolution of the human karyotype (from 48 to 46 chromosomes), a change in the number of the heterochromatin part of the genome, the appearance of hairless skin and changes in the thermoregulation system, which together led to a sharp increase in the size of the brain, with the ensuing consequences.

Facts.

According to modern ideas, the general picture of the evolution of *Homo sapiens* is presented as follows. By 2.4 million years ago new types of hominid had appeared in the fossil record of eastern and southern Africa. About 1.8 million years ago, a new type of early human (*Homo erectus*) appeared in the fossil record of eastern Africa, a species that was persist in Africa for more than a million years. By about 1 million years ago, *H. erectus* was also present in Asia, and may have spread to southern Europe. By about 400 000 years ago, there had been enough changes in certain human populations for a few species of early human to be recognized. This may have marked the emergence of our own species, *H. sapiens*. By 40 000 years ago however modern people – *H. sapience sapience* — to have been the sole occupants of the Europe and Asia [6].

Karyotype.

The evolutionary studies carried out so far seem to indicate that the euchromatic regions of the chromosomes in the different species of primates analyzed are quite similar [7;8]. The main differences in these species are due to the different amounts and localization of heterochromatin [9]. These data are in agreement with those of Dutrillaux et al. [8] according to which heterochromatin is not distributed at random in the chromosomes, but is usually found in the same regions, depending on the species or genera studied.

There are two types of constitutive heterochromatin: C- and Q-heterochromatin. C-heterochromatin is present in the genome of all higher eukaryotes. However, for unknown as yet reasons, at late stages of the evolution of life, in ancestor of contemporary three higher primates (*H. sapiens, P. troglodytes* and *G. gorilla*) there appeared a new type of constitutive heterochromatin – Q-heterochromatin. However, the main difference between these species is the presence of wide quantitative variability of chromosomal Q-heterochromatin regions (Q-HRs) only in the genome of human populations [10-15].

Chromosomal C-heterochromatin regions (C-HRs) is available in the genome of all higher eukaryotes, including great apes. However only in the human karyotype there are three pairs of chromosomes (1, 9 and 16) with unusually large blocks of C-heterochromatin. There are no C-HRs of such size on the chromosomes of chimpanzee and gorilla. Thus, by the total amount of constitutive heterochromatin, the human surpasses all other higher primates. And finally, the unique features of the human karyotype include its number; instead of 48, as in other higher primates, he has 46 chromosomes due to the fusion of two pairs of chromosomes [10-13].

Human body heat conductivity.

The heat conductivity as one of the types of physical characteristics of the human body has never been purposefully studied by anyone, although from a physical point of view it is impossible to deny this possibility. Heat conductivity (HC) from the point of view of physicists is the transfer of energy from more heated parts of a body to less heated bodies as a result of thermal motion and interaction of micro particles. HC leads to equalization of body temperature. As is known, HC due to energy transfer is one of the three transfer phenomena existing in Nature (heat conductivity, diffusion and internal friction, or viscosity). All substances have HC: gases, liquids and solids. In solids, unlike gases and liquids, convection is impossible, so heat transfer is carried out only by thermal conductivity.

In fact, there is nothing new in the very idea that the human body should have some HC. Nevertheless, HC, as an important physical characteristic of the human body, has not yet attracted the attention of either physicists or physiologists. Apparently, this is due to the known physical heterogeneity (in the sense of density) of the human body. Perhaps that is why we could not find in the literature not only a special method, but even any attempts to evaluate the body heat conductivity (BHC) of living organisms *in vivo*.

At present, we have the data that the constitutive heterochromatin constitutes the structural basis of the variability of the human BHC in population [16]. Human BHC is restricted by individual cells, where heat is transferred between nucleus and cytoplasm within the cell – cell thermoregulation [17,18]. There is a significant intra population variability in regard the levels of the human BHC, and it is connected with the amount of chromosomal Q-heterochromatin regions (Q-HRs) in his genome [13,16,19]. We assume that because of great amount of constitutive heterochromatin in the human genome in comparison with other higher primates, the human body became to be distinguished by the greatest heat conductivity.

Human Skin.

Skin is the largest organ in human body, and weighting about 10 kg in adults its area is more than 1.8 m^2. Skin is a large sense organ, separating and at the same time connecting with the outside world, where receptors, which perceive signals from the external and internal environment are located. Skin sensitivity increases with decrease of hair follicle (palms, lips, some part of genitals, sole), i.e., the hairless skin is rather rich in various sensory receptors. Animals, including human beings, in principle can exist without organs of eyesight, hearing, smell and taste, but they cannot exist without the organ of touch. Because it cannot be "shut off", it is a constant state of readiness to receive messages. Touch is the first sensory system to develop, and it will continue to function even after sight and hearing have failed. The term touch includes several tactile senses: pain, pressure, temperature and muscle movement. Many sensory receptors at different levels in the skin are responsible for conveying the nerve signals from thermal, mechanical, chemical and electrical stimuli [20].

Human brain.

In fact, the human brain, without taking into account its psychophysiological features, is a gel-like organ weighing 1,200-1,400 g in an adult, which makes up 2% of the total body weight. But at the same time, he consumes about 20%, and in children up to 50%, of the incoming energy. Thus, the brain is the most energy-consuming organ in the human body. However, a man is not the only owner of a large brain. There are animals whose brains are larger than those of humans (e.g., whales, elephants, killer whales). There is evidence that Neanderthals had a larger brain than modern humans. And the hominid named *Homo Longi*, or "Dragon Man", which existed 140,000 years ago in China, had an even bigger brain.

Interpretations.

We believe that the increase of the human brain size was not the result of drastically changes of the structural genes. Most likely it was the consequence of more ordinary events, such as evolution of karyotype, constitutive heterochromatin in chromosomes, BHC, skin and thermoregulation.

The chain of long events that eventually led to the emergence of a large human brain appears to us schematically as follows. Apparently, the process began from the time when, for unknown reasons, a new type of constitutive heterochromatin – Q-heterochromatin – appeared in the karyotype of the ancestors of three higher primates (*H. sapiens, P.*

troglodytes and *G. gorilla*), in addition to the already existing chromosomal C–heterochromatin. Then, in the heterochromatin part of the genome of direct ancestors of modern man some changes occurred about 100 000-150 000 years ago; on three pairs of autosomes (1, 9 and 16), and on the Y chromosome unusually large C- heterochromatin regions appeared, which do not exist in karyotypes of chimpanzee and gorilla. Thus, by the total amount of constitutive heterochromatin the genome of the *H. sapiens* turned out to be richest one.

We assume that assemblage of the greatest amount of constitutive heterochromatin in the *H. sapiens* genome among the higher primates was the turning point in the human evolution. As we have already demonstrated earlier, the number of chromosomal Q-HRs in the genome is related to the heat conductivity of the human body, namely, the more chromosomal Q-HRs, the higher the human BHC level [16]. Therefore, this event, under certain circumstances, could lead to the disappearance of the hair on his skin. The latter turned out to be the main factor responsible for the increase in the brain size of *H. sapiens* (for more details, see [21]).

Let's imagine such a situation; in search of food, some population of the ancestors of modern man found himself near a tropical lake rich in high-calorie food. However, such luck has confronted individuals in the population with a very serious adaptive problem. The fact is that the consumption of high-calorie food will inevitably lead to the production of excess thermal energy, which must be removed outside the body in a timely manner so as not to disrupt the temperature homeostasis in the body in a tropical climate. This problem was especially aggravated due to the presence of a fur, which prevented the effective removal of excess heat outside the body. As we believe, it was this problem that eventually led to the disappearance of the fur.

However, having successfully solved this adaptive problem, our ancestors eventually faced an even more difficult task when the tropical climate of East Africa began to change for the worse and/or when they began to populate new, but cooler territories. Here, the main harmful environmental factor turned out to be cold, which has been haunting and haunting man to this day, because *Homo s. sapiens* was and remained a single tropical biological species. This problem, as we believe, was solved at the genome level, in this case by changing the number of chromosomes (from 48 to 46), the amount and localization of their heterochromatin regions [22,23].

Some additional clarifications may be required here. In this case, it was important not so much to reduce the number of chromosomes, but to change the number and distribution of chromosomal Q-HRs in the karyotype in the sense that a completely new type of hereditary variability appeared – the variability of the number of Q-HRs in the genome of individuals in the population, which turned out to be truly fateful in the emergence of modern man. This new kind of variability armed man with a new adaptive means in his fight against the cold and hot. It turned out that in the new karyotype, chromosomal Q-HRs in individuals in the population are distributed in such a way that as a result of which it became possible to have children with different numbers of Q-HRs with all the consequences for the organism, especially when concerned the level of human BHC (for details see [22,23]).

Thus, as we believe, the naked skin was a result of long series of events, each depending on the other, and each unpredictable and unique. Apparently, the main reasons for appearance of hairless skin were the following factors: 1) increase of BHC because of high Q- and C-HRs content in the genome of the direct ancestor of modern human; 2) quantitative and qualitative changes of the diet composition [5,24,25], which lead to increase of heat production in the organism demanding efficient heat loss from the body for preservation of temperature homeostasis; 3) tropical climate of Africa, where the ancestors of the *H. s. sapiens* inhabited, had a strong selective influence on such organisms because their bodies have changed towards high heat conductivity. It is possible that in such conditions the best solution of the thermoregulation problems was modification of skin: loss of hairy cover, increase of its heat dissipation ability by increase of the amount of the eccrine glands, blood vessels, and other changes. Given this, the heat-protection function of hair passed over to the layer of subcutaneous fat. Without going into further detail, it can be argued that in the process of evolution skin ceases to be only the barrier-protective organ, it also becomes the organ of sense.

It is believed that the loss of hair was beneficial for human in the sense that if he were not naked, he would not begin to manufacture clothes, which is impossible without availability of fine instruments like awl, needle, and other instruments, production of which is connected with fine coordination of hands' movements. Fire striking and dwelling construction is also impossible without skillful hands even with availability of high intellect. Naked skin made the human not only improve his labor; it also promoted the brain development in another direction. It is possible to say that with appearance of skin a vast area of body has been formed provided with highly differentiated and fine receptors of different signals both from the outer and inner environment. Brain function became more complex, and brain function started to develop [26].

The role of the skin in the evolution of modern man was not limited only with the emergence of a large human brain. The evolution of skin color played an important role in human adaptation to changing environmental conditions. We have devoted a special study to this issue [27,28]. In particular, we believe that the skin color is involved in adaptation to heat and cold climates through changes in human thermoregulation systems.

That is as the folk say: "Every cloud has its silver lining". A human, instead of his hair that he has lost, acquired clothes, which is more important in sense that in addition to body protection from cold (physiology) it has an important ethnical and cultural, psycho-emotional, social and economic importance that promotes the scientific and technical progress. In addition, the latter facilitates functioning of the temperature homeostasis in human. Therefore, in reply to the old question, namely: "has a human survived because he became intelligent, or, he became intelligent only because he managed to survive", we have chosen the second version [13,29,30].

The common ancestor of man and apes was a tropical creature, and members of the human family did not spread out of the tropics and subtropics until about a million years ago. Today there are more than 7 000 million of us, found all over the earth's surface. The human species can tolerate such a range because each of us carries a tropical microenvironment in the form of clothes and dwellings (tropicalization). We assume that the apes could not leave the boundaries of tropical Africa as they were not able to tropicalize the microenvironment around their bodies, and their hair cover was not sufficient enough to protect the organism of these heat-loving animals even in conditions of Africa savanna climate [31,32].

Here, perhaps it should be especially highlight two more important aspects of the role of human BHC variability in the formation of modern man. The first is the role of the wide variability of the human BHC level in human adaptation to new conditions different from the climate of East Africa, in particular, to heat and cold [13]. There is evidence of the possible selective value of chromosomal Q-HRs: a) consistent interpopulation differences in the quantitative content of chromosomal Q-HRs in their genome were established [14,32-45]; b) these differences proved to be related to features of the ecological environment of the place of permanent residence, and not to their racial and ethnic composition [14,29]. c) the amount of chromosomal Q-HRs in the population genome tend to decrease from southern geographical latitudes to northern ones, and from low-altitude to high-altitude ones [38-45]. We suppose that *H. sapiens*, besides those inherent in all mammals possesses an additional but very fine and simple mechanism of thermoregulation. In the present case, in order to preserve temperature homeostasis under different environmental conditions, in addition to physiological, behavioral and biochemical mechanisms such as wide variability by BHC was used [29,31,46,47]. Possibly, for the *H. sapiens* BHC diversity is necessary because no single genotype can possess a superior adaptadness in all environments.

The second aspect of the question concerns the thermoregulation of the brain. As is known, the human brain is the most energy-consuming organ and about 20% of all available energy in the body is spent on its work. Obviously, this process will inevitably be accompanied by the release of a huge amount of excess heat energy in the brain, especially because of its relatively small proportion (about 2%) of the total body mass of a human. In this sense, there should be nothing unexpected in the statement that the role of high human BHC is especially important in the dissipation of this excess heat from the brain. Moreover, we believe that the ability of the human brain to consume so much energy is not related to the ability of a man to easily obtain high-calorie food, but to the ability of his highly heat-conducting body to efficiently remove excess thermal energy outside the body. Apparently, it is no coincidence that the human brain has an additional thermoregulation system, because even a slight increase in brain temperature (f.e., when drinking strong alcoholic beverages) is associated with serious violations in its functioning.

Discussion

Of course, it is impossible to test our hypothesis experimentally in detail. However, it is quite possible to verify some of its key points at the cellular, organismal and population levels. At the cellular level, it is possible to examine the influence of the number of chromosomal HRs in the genome on the cell thermoregulation; namely, in the cells culture of human and two other great apes to compare speed the dissipation of heat from the nucleus at a change of temperature in the thermostat above 37.0 ^{0}C. At the organismal level to compare the level of the BHC of these three higher primates *in vivo*, as we have done it in the human populations [16-19]. The assumption that modern man could have originated from a single population has already received some confirmation. In particular, we have shown that according to the distribution pattern of chromosomal Q-HRs on seven Q-polymorphic autosomes (3, 4, 13-15, 21 and 22), the populations surveyed by us from different regions of Eurasia and Africa do not differ significantly [50]. This may indicate that modern humans may have originated from a single ancestral population [13-22]. It would be desirable to repeat similar comparative cytogenetic studies on different populations living on other continents.

One of the more surprising features of human evolution is that the brain in the Neanderthals was actually larger than modern human brains, and we now know that it is unlikely that Neanderthals were our ancestors [48;49]. And then, certainly more than fifty thousand years ago, and perhaps as much as one hundred thousand to two hundred thousand years ago, a transformation happened. The brain of the humans of the last hundred thousand years have clearly been functioning differently from those of the two and half million or so years before at least because technology, art, religion and warfare developed quickly. What happened to bring about the transformation? On the other hand, no changes in brain size were associated with the explosive developments in culture, knowledge and social organization over the past one hundred thousand years. Therefore, all social hypotheses relating to the size of the human brain such as food gathering, hunting, scavenging, home base behavior, defense against carnivores, and the need to communicate within relatively large social groups do not seem entirely convincing to us.

High physiological plasticity and perfect system of physiological thermoregulation, for all their importance for the normal functioning of the human body, are mainly quantitative, not qualitative, and apparently were secondary factors in the emergence of a large brain in man. The structural features of the upper limbs of man were undoubtedly important for increasing the size of his brain, but their role in the development of mind has not been proven. As for other morphophysiological features of humans, they were developed to varying degrees in many other animal species could play a role in the development, including the size of the brain, but hardly played a significant role in the emergence of mind.

Among other possible, non-morphophysiological features of a man, the role of highly developed speech in a sharp increase in the size of his brain is most often discussed. It really seems reasonable to expect that a more developed and complex language requires a larger brain. However, the fact that the size of the brain of a modern man with the development of writing, literature, art and science has not changed significantly in recent 5000 - 10 000 years compared to the representatives of *H. sapiens*, who lived before their exodus in Africa, they do not speak in favor of social factors in changing the volume of the brain.

Thus, the reasons for the emergence of reason in man are complex, but there is no reason to believe that we suddenly emerged as Athena from the head of Zeus. No, it was a completely natural process; the gradual complication of the brain, as a result of adaptation to living conditions, and we, in this sense, did not stand out in any way, until quantitative changes turned into qualitative ones and the brain overcame the barrier at which the complication of the brain turned into a process with positive feedback.

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